A Plan for the Near Future of High Energy Neutrino Physics

at the Homestake Laboratory

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The future of moderate and high energy neutrino physics in the U.S. has recently taken a dramatic turn for the better. Two important events have occurred that form the basis of this claim. First, the NSF, in searching for a site to serve as a deep underground laboratory for science and technology (DUSEL) has selected two of eight proposed sites as finalists in the competition, and placed DUSEL on the list of projects it proposes to consider funding in the near future. Second, the state government of one of the finalists, the Homestake Mine in Lead, South Dakota, has appropriated sufficient funds to convert the mine to a proto-laboratory before federal government funds might be expected according to the NSF plan.

This note is meant to serve as a letter of interest in the construction of the cavities and detectors for an intensive program of neutrino physics and nucleon decay in the Homestake Laboratory.

The future of the Homestake Laboratory as the center of massive detectors for neutrino physics in the U.S. will then be assured for the several decades it will take to explore neutrino oscillations and CP invariance violation in the neutrino sector, and to measure the parameter $\sin^2 2\_{13}$ if it is greater than approximately 0.001, about 100 times smaller than the present experimental upper limit.

Now is an excellent time to proceed with a several year old plan, outlined in **Phys. Rev D <u>68</u>, 012002(2003) and XiV: hep-ex/0306053 v1 26 June 2003,** among others, to investigate neutrino oscillations over a long (>1000 km) neutrino flight path. That plan called for the construction of a number of 100 kiloton Cerenkov detectors at Homestake.
In the beginning of 2002, the former chief mine engineer at Homestake worked out a construction plan and budget for 50 meter diameter by 50 meter high vertical cylinder shaped chambers. Each of these had approximately 100 kiloton water capacity. The excavation cost for a single chamber was $17 million while the cost for constructing three simultaneously was less than $15 million each. The excavation time was 4 years for the complete construction of either a single chamber or three chambers constructed in parallel. These chambers will be the largest ever constructed in a deep underground location, but studies of the rock strength and existing cavities at Homestake indicate that they can be successfully constructed. Considerable interest has been expressed by geoscientists, particularly rock mechanics people, in monitoring the plans and excavations of these chambers.

As a first step, construction of a _ volume chamber, about 25 kilotons, can begin as soon as the Homestake Laboratory is ready for science. From scaling, excavation of this chamber should cost about $6 million and take about 18 months to complete. It will serve as an important neutrino detector as well as provide an excellent model to test the stability predictions of rock mechanics and the construction procedure for the larger, 100 kiloton chambers. As soon as this first excavation is completed, and the stability verified, the parallel construction of two 100 kiloton chambers can begin. These excavations could be finished in the latter half of 2012 or early 2013 depending on the flow of funds.

The 25 kiloton detector, 30m in diameter by 35m high, can be functional for physics by the end of 2010. It will have approximately the same fiducial volume as SuperK. Once the large detectors are operational, the smaller, 25 kiloton detector might be, for example, converted from a water Cherenkov detector to a liquid scintillator detector. (See, for example, the proposal HSD, BNL-UCLA workshop 3/1/05.)

The recently issued Mission Need Statement by the Director of the Office of Science of the Department of Energy, Ray Orbach, for “A generic accelerator-based electron neutrino appearance experiment to measure neutrino mixing and to probe the neutrino mass hierarchy” and the soon to be issued Statement for a new initiative for “A high intensity neutrino beam (Super Neutrino Beam) for neutrino CP-violation experiments” emphasize the importance of this program and the need to make it a high priority effort at the Homestake Laboratory.

The fundamental nature of the neutrino physics to be undertaken with massive neutrino detectors at Homestake Laboratory and the opportunity to pursue that physics at length will make Homestake one of the dominant centers of neutrino physics in the world because the depth and large underground areas available at Homestake will make it possible to house experiments not available to most other laboratories. These properties of Homestake will set it apart, and do so as early as 2010, with a relatively modest investment beginning in 2007. We urge that this effort move forward now.

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